Journal of Traumatic Stress, Vol. 17, No. 4, August 2004, pp. 303–310 (© 2004)

A Mediational Model of PTSD in World War II Veterans Exposed to Mustard Gas

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Structural equation modeling (SEM) was used to examine associations among trauma-related contextual factors, initial psychological reactions, social support, and subsequent disclosure on posttraumatic stress disorder (PTSD) symptoms in a sample of World War II (WWII) veterans exposed to mustard gas ($N = 305$). A structural model suggested that initial psychological reaction mediated the relationship between variables related to the context of mustard gas exposure and severity of PTSD symptoms 50 years later. Unexpectedly, social support appeared to be positively related to PTSD symptoms, and not related to the contextual variables or initial psychological reactions. These findings contribute to our understanding of PTSD in older veterans, and have relevance for early intervention services to prevent PTSD among those at risk for exposure to toxic agents.

KEY WORDS: PTSD; WWII veterans; contamination stressor; initial psychological reaction; risk and protective factors.

During World War II (WWII), the United States military conducted a secret research program to test equipment for protecting military personnel against the effects of mustard gas and a similar compound, lewisite (Pechura & Rall, 1993). Exposure to these compounds has been found to cause long-term physical health problems including chronic bronchitis, conjunctivitis, skin ulceration, and even some forms of cancer. The tests required men to either remain in a chamber with the gas or enter a field that had been contaminated with the gas.

Mustard gas exposure meets the *Diagnostic and statistical manual of mental health fourth edition* (DSM-IV: American Psychiatric Association, 1994) A1 criterion for a traumatic stressor. It also has aspects of being a contamination stressor: it has both acute and chronic impact; it involves uncertainty about health problems; and fears are intensified out of concern that the stressor is being concealed by authorities (Green, Lindy, & Grace, 1994). Mustard gas exposure fits this description insofar as many veterans were not adequately informed about the potential harmful effects of exposure, and many felt considerable fear about future consequences of exposure to their health.

Schnurr et al. (2000) estimated the prevalence of PTSD in a randomly selected sample of these veterans to be 32%. Mustard-gas-related PTSD was associated with greater number of exposures, being ordered to participate, lack of preparation, having physical symptoms during the test, seeing others in distress, and being prohibited from disclosure. Schnurr et al. did not, however, examine how these factors interact to predict PTSD.

A number of risk and protective factors for the development of PTSD have been identified. Among these factors are the context of a traumatic experience and how people initially respond. The context of a traumatic event

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0894-9867/04/0800-0303/1

can include such elements as characteristics of the trauma and circumstances that impact how a person experiences a traumatic event. McCarroll, Ursano, Fullerton, and Lundy (1993) found that military personnel working in a mortuary were more likely to have PTSD if they were ordered to do the work as opposed to volunteering, and if they were not prepared for the work. Prohibition from disclosing one's experiences is also part of the context of a traumatic event. For example, enforced secrecy has been theorized to result in worse outcomes for survivors of sexual and physical abuse (Leonard, 1996).

In addition to contextual factors, peritraumatic distress and dissociation have also been shown to predict PTSD (Ozer, Best, Lipsey, & Weiss, 2003). Initial reactions of fear, helplessness, or horror are associated with posttraumatic symptoms (e.g., Brewin, Andrews, & Rose, 2000; Orsillo, Borkovec, & Litz, 1998). Moreover, an initial dissociative reaction also may lead to increased risk for PTSD (e.g., Ozer et al., 2003).

Experiences that occur following exposure to a traumatic event also influence risk for PTSD. For example, availability and use of social support has a mitigating effect on the development of PTSD (Green, Grace, Lindy, Gleser, & Leonard, 1990; King, King, Fairbank, Keane, & Adams, 1998). It is believed that timely disclosure of a trauma can be protective against PTSD, although no studies have tested this hypothesis (e.g., Green et al., 1990).

King and colleagues used structural equation modeling (SEM) to examine interrelationships among risk and protective factors for PTSD in Vietnam veterans (e.g., King et al., 1998). To our knowledge, however, a model of risk and protective factors has never been tested with a contamination stressor, which is of particular significance in light of growing concerns about bioterrorism. The present study builds upon Schnurr et al.'s findings by using SEM to test hypothesized relationships among predictors of posttraumatic symptoms related to mustard gas exposure (Schnurr et al., 2000). Our model is presented in Fig. 1. First, we examined to what extent the effects of contextual factors were mediated through initial psychological reaction. Second, we examined the extent to which initial psychological reaction was mediated through disclosure and social support. Third, we explored whether disclosure had an indirect effect on PTSD symptoms through social support.

Method

For a more detailed report of methods used in this study, see Schnurr et al. (2000).

Participants

Five hundred veterans were randomly sampled from a national registry developed for a mortality study of mustard gas test participants (Bullman & Kang, 1997). Veterans who were alive as of October 1995 comprised the study population. Of the 250 Army and 250 Navy veterans selected, 363 (72.6%) participated; 15.4% could not be located, 7.6% were dead or ineligible (e.g., cognitive dysfunction), 1.0% could not be scheduled, and 3.4% refused. Of those located and eligible, 94.3% participated.

Participants' average age was 71.9 years ($SD = 4.1$). Most were White (97.2%); 9.9% additionally reported Hispanic ethnicity. Most were married (82.9%), retired (77.8%), and had graduated high school (63.6%). Few had a VA psychiatric disability (5.8%), although 51.2% were receiving some kind of disability payment. Almost half (46.3%) had experienced combat.

Measures

On the basis of the hypothesized path model in Fig. 1, four domains were identified: (1) context of mustard gas exposure; (2) initial psychological reaction; (3) post-mustard gas exposure; and (4) PTSD symptoms.

Context of Mustard Gas Exposure

Volunteer status was measured with one item, "Did you volunteer or were you ordered to participate in the testing?," coded as 1 = *volunteered*, 0 = *ordered*.

Participants' level of preparation for the mustard gas tests was measured by an index created from three yes/no items: whether a participant (1) believed he would be exposed to hazardous chemicals during the tests; (2) had received protective training prior to the tests; and (3) felt confident that the protective clothing worn during the tests would prevent injury. Scores ranged from 0 to 3, with higher values indicating greater preparation.

Number of exposures was collapsed into two categories based on the relation between exposure and PTSD (Schnurr et al., 2000). The first category consisted of those who reported either one or two exposures and those who could not recall the number of times they were exposed. These groups were combined because neither 1–2 exposures nor lack of recall was associated with PTSD. The second category consisted of those who reported ≥ 3 exposures.

Prohibition from disclosing participation in the mustard gas tests was based on participants' responses to two

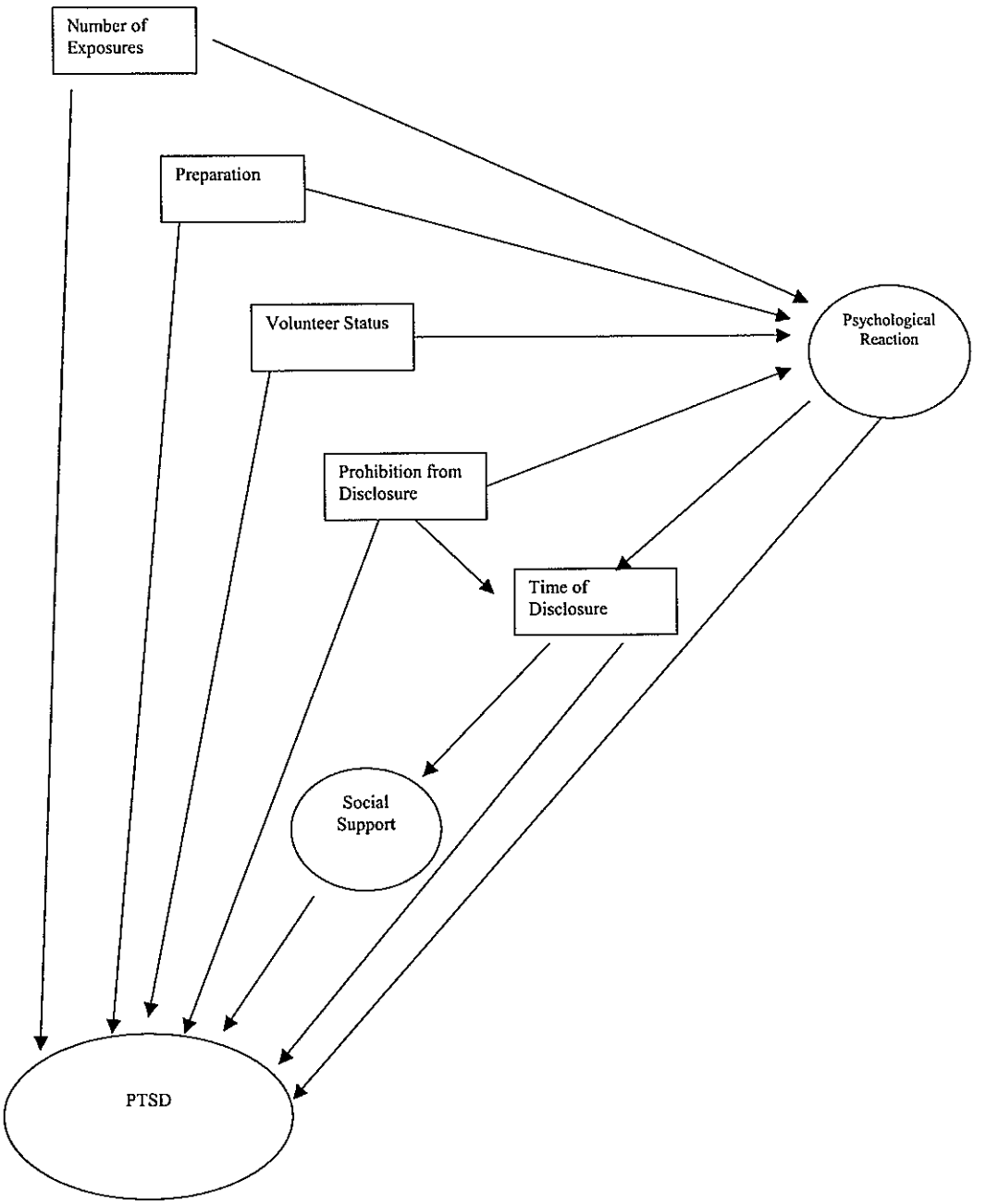

Fig. 1. Hypothesized model of the associations among trauma-related contextual factors, initial psychological reaction, postexposure factors, and posttraumatic stress disorder (PTSD) symptoms.

yes/no items: whether a participant had been (1) sworn to an oath of secrecy about the testing; and (2) told that disclosure would lead to criminal prosecution. Participants who responded affirmatively to either of these items were considered to have been prohibited from disclosure. Those who responded negatively to both items, or said they did not recall, were considered not to have been prohibited.

Initial Psychological Reaction

Adverse psychological reactions were measured on the basis of responses to four yes/no items. One of these items asked participants whether they had experienced fear, helplessness, or horror during testing, and the other three items asked about dissociative symptoms (i.e.,

feeling emotionally numb or detached, feeling in a daze, having the experience of derealization). For correlational analyses, the four items were summed, and scores ranged from 0 to 4, with higher values indicating a more adverse initial reaction. For SEM analyses, initial psychological reaction was operationalized as a latent variable by using the four individual items as indicators.

Postexposure Variables

Social support was measured with a 5-item index that assessed the availability of help or support from others to fulfill specific needs (e.g., love, advice about a crisis; Broadhead, Gehlbach, deGruy, & Kaplan, 1988). Although the wording of the scale implies current support, a time frame was not specified. Each item was answered on a 6-point scale (1 = *all of the time*, 6 = *none of the time*). If participants did not know or refused to answer, their data for that specific item was treated as missing and they were given the average item score of the items they answered. Coefficient alpha was .82.

Time of disclosure was measured by creating a dichotomous variable that indicated whether participants had disclosed their participation in the tests any time through 1990, when information about the tests was publicly revealed. Individuals who reported never disclosing, that they did not know, or that they had disclosed after 1990 were coded as 0. Individuals who disclosed in 1990 or earlier were coded as 1.

PTSD Symptomatology

PTSD symptomatology related to mustard gas exposure within the past month was measured by the PTSD Checklist (PCL; Weathers, Litz, Huska, & Keane, 1994), a questionnaire consisting of the 17 *DSM-IV* PTSD symptoms. Participants were asked to indicate how much they were bothered by each symptom, using a 5-point scale ranging from 1 = *not at all* to 5 = *extremely*. Because the PCL is typically summed and some participants failed to answer all 17 items, items were averaged and then multiplied by 17 to create sum scores for participants who answered at least 75% of the items. Coefficient alpha was .97.

Procedure

Participants were informed about the study by letter. Forty-minute telephone interviews were conducted after interviewers at a survey research firm obtained verbal informed consent and provided assurances of confidentiality and anonymity.

Data Analysis

First, summary statistics and bivariate correlations were calculated for the variables in this study. Next, the hypothesized model depicted in Fig. 1 was tested using SEM as implemented in the $M+$ program (Muthen & Muthen, 2001). A 17 × 17 covariance matrix served as input. This matrix contained all of the single-item measures (e.g., number of exposures) and each item comprising the multi-item scales (i.e., four psychological reaction items, five social support items, etc.), except the PCL. Because a large number of items necessitates estimating a large number of parameters, which increases risk of improper solutions, the 17 PCL items were combined by randomly selecting items to form three "item parcels" (two parcels containing six items and one containing five items). This approach has been advocated from a methodological standpoint (e.g., MacCallum & Austin, 2000) and has been used in other studies of PTSD (e.g., King et al., 1998).

We followed Anderson and Gerbing's two-step approach by estimating first a measurement model and then the hypothesized structural model (Anderson & Gerbing, 1988). Because both categorical and continuous variables were included in the model, we adopted the approach developed by Muthen, and used weighted least squares estimation with robust standard errors (Muthen, du Toit, & Spisic, in press). Assessment of overall fit was based on a number of fit indices. We used the mean- and variance-adjusted χ^2 statistic recommended by Muthen and Muthen (2001) for use in models that include categorical variables. Unfortunately, this statistic does not follow a distribution that can be used for χ^2 difference testing, which precluded the use of Anderson and Gerbing's two-step approach to compare competing models (Anderson & Gerbing, 1988). Because the χ^2 is heavily dependent on sample size, we also used the ratio of this χ^2 to its *df*s. Other fit indices used to assess overall model included the root-mean-square error of approximation (RMSEA; Browne & Cudeck, 1993) with the adaptation described in Muthen and Muthen (2001), Tucker-Lewis index (TLI; Tucker & Lewis, 1973), the Comparative Fit index (CFI; Bentler, 1990), and weighted root-mean-square residual (WRMR; Muthen & Muthen, 2001). In evaluating the χ^2/df ratio, values <2 are usually considered indicative of good fit (Carmines & McIver, 1981). TLI and CFI values >.90 (Browne & Cudeck, 1993) or .95 (Hu & Bentler, 1999) indicate adequate fit of the model to the data, whereas

Table 1. Bivariate Correlations and Descriptive Statistics for Variables Used to Predict Posttraumatic Stress Disorder Symptoms in Mustard Gas Test Participants ($N = 305$)

Variables	1	2	3	4	5	6	7	*M*	*SD*	Observed range
1. Number of mustard gas exposures								0.25	0.43	0–1
2. Volunteer status	−.05							0.79	0.41	0–1
3. Preparation	−.04	.00						1.84	0.91	0–3
4. Prohibition	.08	−.06	−.16**					0.47	0.50	0–1
5. Time of disclosure	−.02	.11	.02	−.28***				0.58	0.49	0–1
6. Social support	.05	−.02	−.02	−.04	−.07			2.14	1.15	1–6
7. Initial psychological reaction	.15**	−.32***	−.18**	.30***	−.08	.06		1.10	1.36	0–4
8. Posttraumatic stress disorder	.15**	−.31***	−.24***	.35***	−.08	.14*	.63***	36.17	18.49	17–80

*$p < .05$. **$p < .01$. ***$p < .001$.

RMSEA values <.05 (Browne & Cudeck, 1993) or .06 (Hu & Bentler, 1999) indicate acceptable fit. For the WRMR, Muthen and Muthen suggest that values <.90 indicate a good fit in models containing both continuous and categorical variables. Individual paths were evaluated with *t* tests, or critical ratios, calculated by dividing parameter estimates by their *SE*s.

Results

Table 1 displays descriptive information and bivariate correlations among the variables. PTSD symptoms were related to mustard gas exposure, volunteer status, preparation, prohibition, and initial psychological reaction, as expected (correlations ranging from .15 to .63). PTSD symptoms were unexpectedly related to greater reported social support. In addition, number of exposures, preparation, volunteer status, and prohibition were related to initial psychological reaction. Time of disclosure was unrelated to social support, and initial psychological reaction was unrelated to time of disclosure. Prohibition from disclosure, however, was significantly related to time of disclosure.

First, we examined the measurement model. In this model, the three latent variables (initial psychological reaction, social support and PTSD, each measured by their respective indicators) and five observed variables (number of exposures, preparation, volunteer status, prohibition, and time of disclosure) were allowed to freely correlate with one another. The results for this model suggested good fit, $\chi^2(34, N = 305) = 46.56$, $p > .05$, χ^2/df ratio < 2. The TLI and CFI were both .99, the RMSEA was .04, and the WRMR was .64.

Next, we examined the structural model. In this model, rather than letting the variables freely correlate, we constrained them to the relationships hypothesized in Fig. 1. The model fit the data well, $\chi^2(29, N = 305) = 37.08$, *ns* ($\chi^2/df$ ratio < 2, TLI = .99, CFI = .99, RMSEA = .03, WRMR = .80).

The results for specific paths within the model (standardized parameter estimates) are presented in Fig. 2. Paths were specified according to the hypotheses involving the direct and indirect relationships among contextual variables, initial psychological reaction, postexposure variables, and PTSD symptoms. Paths pointing to categorical observed variables represent the probability of being in one of the categories. Significant paths are represented by solid lines, and nonsignificant paths are represented by dotted lines.

Our primary question was to what extent the contextual variables would relate to PTSD indirectly through initial psychological reaction. As can be seen in Fig. 2, our primary hypothesis was strongly supported. All four contextual variables (number of exposures, preparation, volunteer status, and prohibition) had indirect effects on PTSD symptoms through initial psychological reaction. Three of the four contextual variables (preparation, volunteer status, and prohibition) also had direct effects on PTSD symptoms. Prohibition was significantly related to time of disclosure.

Our second prediction, that initial psychological reaction would be mediated through time of disclosure and social support, was not supported. Initial psychological reaction was only directly related to PTSD symptoms. Third, we predicted that time of disclosure would be indirectly related to PTSD through social support, which also was not supported by the analyses. Time of disclosure was not directly or indirectly related to PTSD symptoms. Social support was related directly to PTSD symptoms. Direct and indirect effects of all variables on PTSD symptoms are presented in Table 2.

Discussion

This study tested a model of risk and protective factors to predict PTSD in WWII veterans who were exposed to mustard gas. The current study extended the work of Schnurr et al. (2000), which found high rates of current

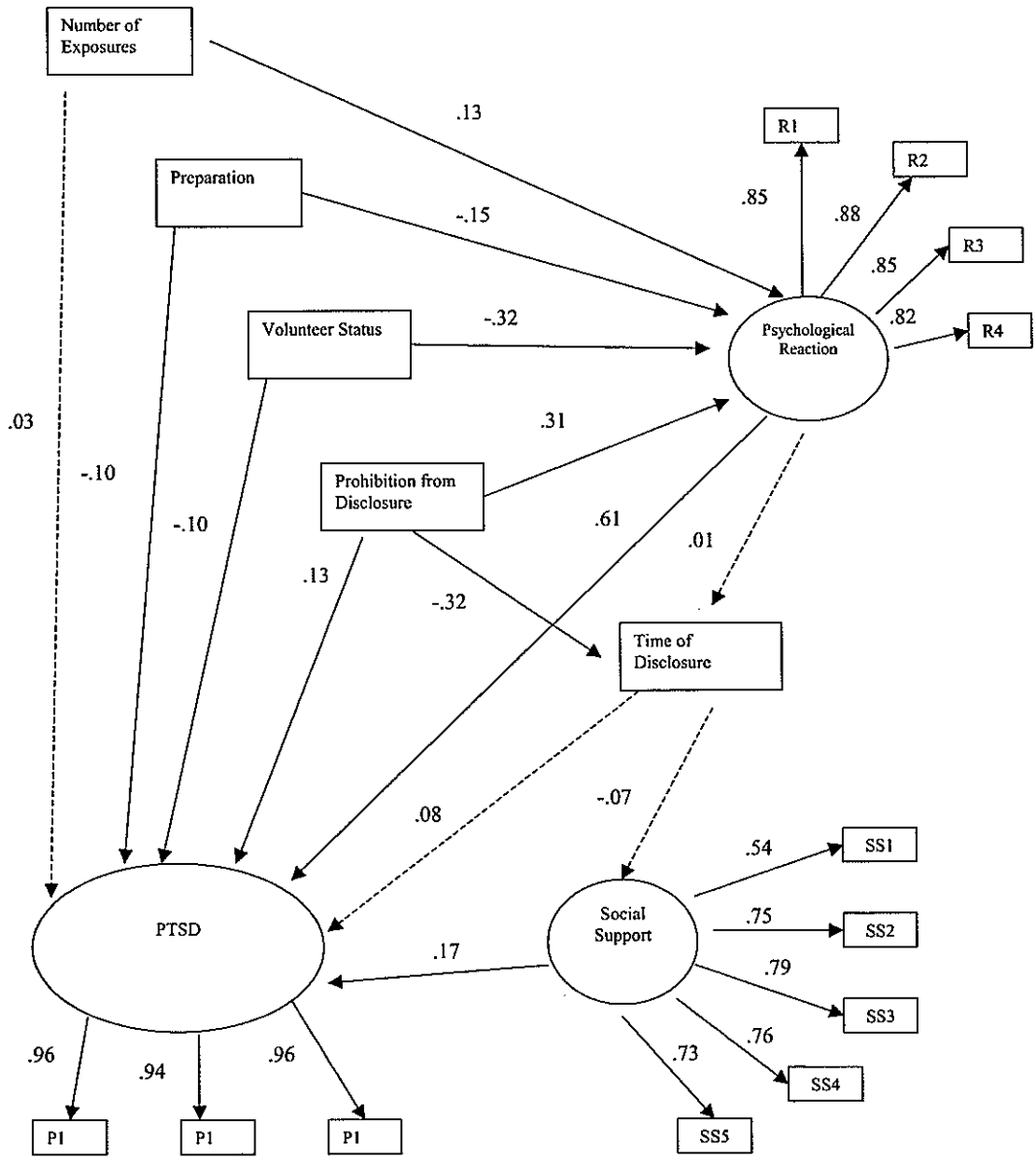

Fig. 2. Structural model: The influence of trauma-related contextual factors, initial psychological reaction, and postexposure factors on posttraumatic stress disorder (PTSD) symptoms in World War II veterans exposed to mustard gas ($N = 305$). Solid lines represent significant paths and dotted lines represent nonsignificant paths.

PTSD among these veterans, by examining interrelationships among posttraumatic symptoms and variables related to the context of mustard gas exposure, immediate psychological reaction to exposure, disclosure to others, and social support.

A primary finding in the current study was the extent to which initial psychological reaction seemed to mediate the effects of contextual variables on PTSD symptoms. Number of mustard gas exposures, volunteer status, preparation, and prohibition from disclosure were related to PTSD symptoms as much or more on an indirect mediated basis (through initial psychological reaction) as they were directly related to PTSD symptoms. Therefore, an initial adverse psychological reaction may be a key factor in determining whether the peritraumatic contextual factors put these men at risk for developing PTSD symptoms because of toxic exposure.

Psychological reactions at the time of mustard gas exposure had the strongest association with PTSD symptoms, consistent with findings from a recent meta-analysis

Table 2. Effects of Trauma-Related Contextual Factors, Initial Psychological Reaction, and Postexposure Factors on PTSD Symptoms in Mustard Gas Test Participants

Variables	Indirect effects	Direct effects	Total effects
Number of exposures	.08	.03	.11
Preparation	−.09	−.10	−.19
Volunteer status	−.20	−.10	−.30
Prohibition	.17	.13	.30
Time of disclosure	−.01	.08	.07
Social support	.00	.17	.17
Initial psychological reaction	.00	.61	.61

Note. PTSD = posttraumatic stress disorder.

of predictors of PTSD (Ozer et al., 2003). Evidence from prospective studies suggests that strong peritraumatic stress or dissociative reactions may lead to psychobiological changes such as fear conditioning (e.g., sensitization) or overconsolidation of trauma memories (Bryant, 2003). Our findings, although retrospective and requiring replication, suggest these effects may persist for decades in some cases. There are significant potential limitations to the design of this study that provide reason for caution in interpreting these findings. First, the retrospective nature of this data, and in particular, reports of initial psychological reaction 50 years later, raise some question about the accuracy of recall for this information. Memory errors would be expected over such a significant length of time, and although efforts were made in the construction of the interview to address this problem, it could be difficult for some men to remember details of their experience. Second, given the cross-sectional, correlational nature of the present data, we cannot be certain that initial psychological reaction is causal. Moreover, our measure of initial psychological reaction did not include all aspects of initial reaction (e.g., acute physiological arousal). Despite these limitations, this study adds to the literature by offering further support with a type of traumatic stressor not heretofore examined in this paradigm for the importance of peritraumatic stress and dissociative reactions as potential risk factors for PTSD.

Our findings were consistent with those of Schnurr et al. (2000). Less preparation, being ordered to participate in the tests, and being prohibited from disclosing to others were associated directly with more posttraumatic symptoms. These event-related variables were only partially mediated through initial psychological reaction. Number of exposures, however, was associated with PTSD symptoms only through initial psychological reaction, suggesting that extent of exposure was related to PTSD symptoms only if there was a subjective response of intense distress or dissociation.

We failed to find evidence that the effect of a veteran's initial psychological reaction on PTSD was mediated through postexposure social support and time of disclosure, or that the effect of disclosure was mediated through support. It may be that factors other than the timing of disclosure, such as others' reactions to the disclosure, are more critical in determining the outcome of disclosure. Unfortunately, such information was not available in the present study.

Unexpectedly, higher levels of perceived social support were associated with greater PTSD symptoms. This finding is contrary to findings with Vietnam veterans (e.g., Green et al., 1990; King et al., 1998) of an inverse relationship between social support and PTSD symptoms. However, in the broader literature examining stress, coping, and social support, studies have found that people who experience greater amounts of stress engage in more coping strategies and report utilizing more social support than those who are less stressed (Vaux, 1988). Individuals who have more PTSD symptoms may have a greater need for social support, and are thus mobilizing and utilizing more social support relative to men who have none or few PTSD symptoms. As such, PTSD symptoms may be driving the increased report of social support instead of social support serving as a buffer against PTSD symptoms.

The study has several additional limitations worth noting. Related to the retrospective design issues, there may have been a retrospective bias, causing overreporting of exposure, initial distress, and other risk factors among men with a higher level of PTSD symptoms, or underreporting among men with fewer symptoms. Although it would have been preferable to have studied these men earlier in order to avoid the above-mentioned recall problems, such a study would not have been possible in light of the secrecy surrounding these tests. Our measure of social support was also limited; no time frame was specified and it did not assess for other aspects of social support that are likely important, including use of support and perceived helpfulness of the support.

This study also has important strengths. It contributes to our growing understanding of PTSD in older veterans, and to our understanding of the long-term effects of exposure to toxic substances. Moreover, by highlighting the association between PTSD and both contextual factors and initial psychological reactions, our results may have implications for the development of early intervention services to prevent PTSD among military personnel or other disaster or emergency responders who are or could be exposed to toxic agents. Rigorous tests are urgently needed to develop and evaluate early interventions designed to address these potential risk factors.

Acknowledgments

The authors thank Lynda King and Dan King for providing feedback on an earlier draft of this paper, and John Boyle and staff at Schulman, Ronca, and Bucuvalas, Inc. for their assistance in conducting the project.

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